Accelerated Fluctuation Analysis by Graphic Cards and Complex Pattern Formation in Econophysics

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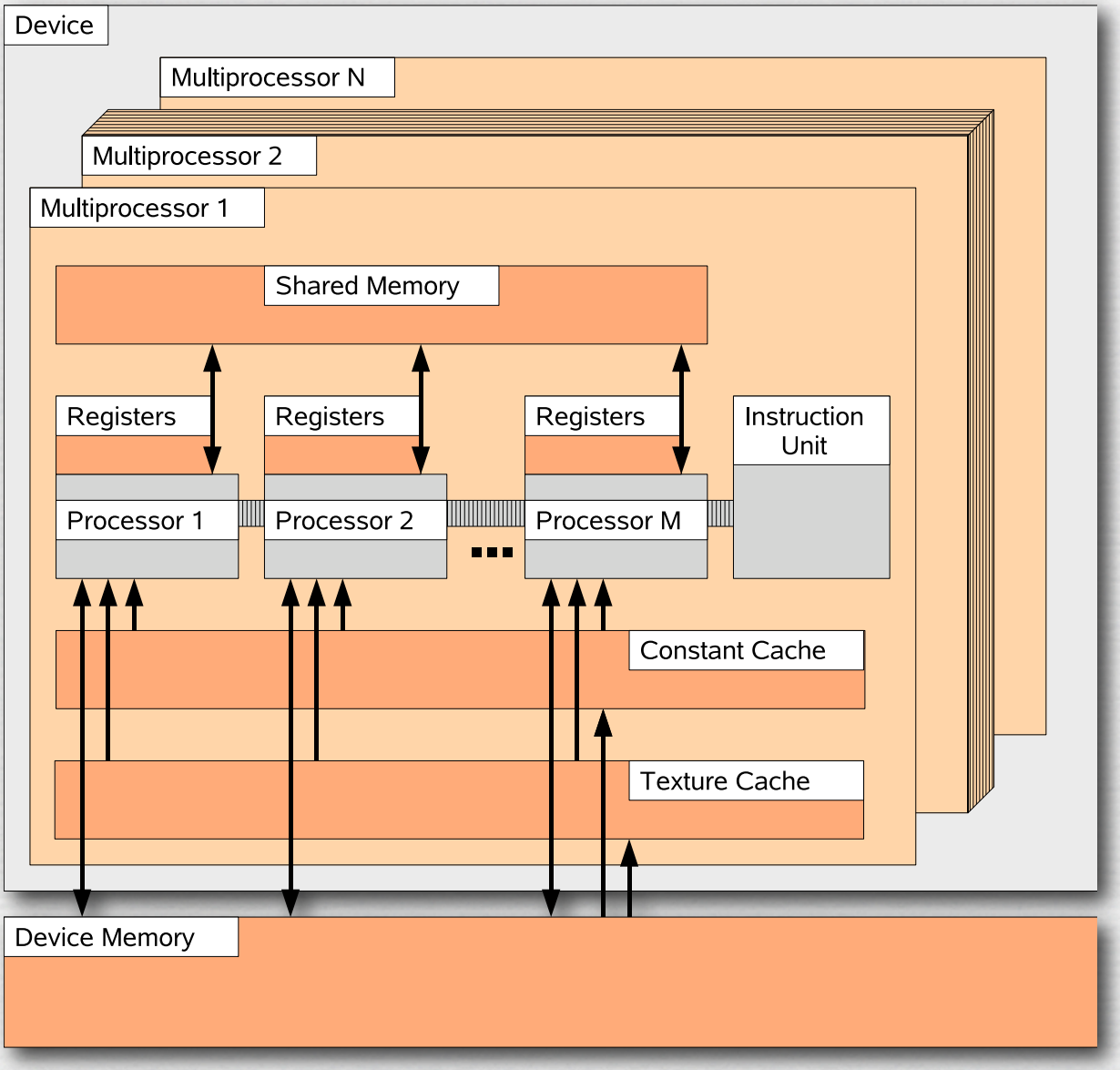
With thanks to: Peter Virnau, Wolfgang Paul, and Johannes J. Schneider

Reminder: GPU device architecture



GeForce GTX 280:

Global memory 1024 MB

Number of multiprocessors 30

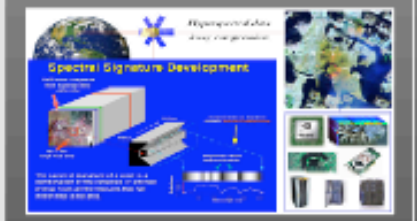
Number of cores 240

Constant memory 64 kB

Shared memory 16 kB

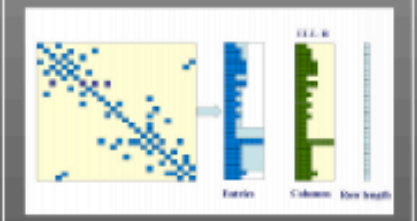
Clock rate 1.30 GHz

LATEST CUDA NEWS CSI-Style Video Enhancement For Consumers



Hyperspectral image compression on NVidia GPUs

26 x



The sparse matrix vector product on GPUs

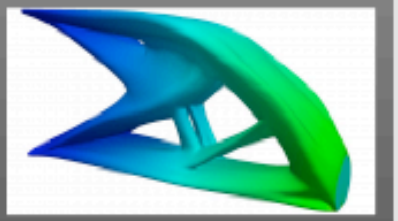
80 x

cRARk

15 x

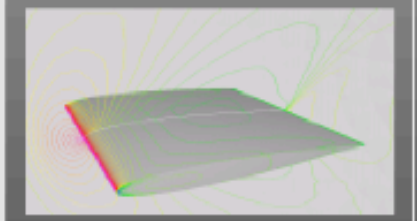
Density field viewer

10 x



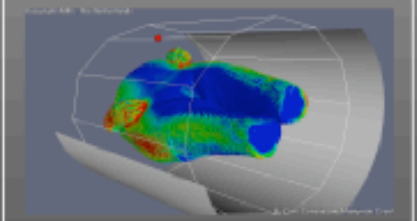
GPUTop - Topology Optimization on CUDA Graphics Cards in 3D

60 x



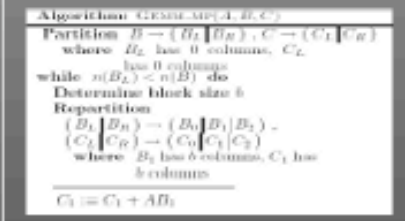
Running Unstructured Grid CFD Solvers on Modern Graphics Hardware

33 x



Parallel Computation With NVIDIA Graphics Card Using CUDA in Hyperthermia

25 x

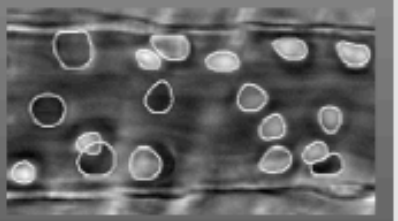


Level-3 BLAS on a GPU: Picking the Low Hanging Fruit

4 x

Parallelized Turing bombe & Enigma simulations

35 x

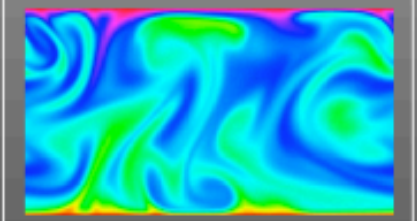


Accelerating Leukocyte Tracking using CUDA

29 x

Real Time Holographic Optical Trapping

350 x

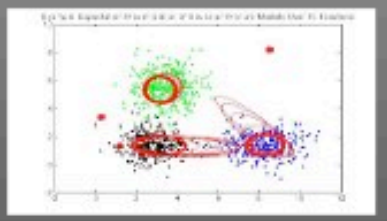


A Fast Double Precision CFD Code using CUDA

8 x

Clustering Billions of Data Points Using GPUs

300 x



CUDA Accelerated Expectation Maximization of Gaussian Mixture Models

170 x

GPU accelerated Monte Carlo simulation of the Ising model

60 x

DOWNLOAD AND INSTALLATION TIPS

NVIDIA's CUDA development tools provide three key components to help you get started: the latest CUDA driver, a complete CUDA Toolkit, and CUDA SDK code samples.

Please download files and install them in this order:

Source: http://www.nvidia.com/cuda

1. CUDA Driver **2. CUDA Toolkit** **3. CUDA SDK code samples**

The CUDA driver and Toolkit installation are required before running the precompiled examples or compiling the example source code.

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Source: http://www.nvidia.com/cuda

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CUDA Plug-in Documentation

MathWorks MATLAB® Plug-in	Download
CUDA Photoshop Plug-ins (documentation): Source code examples for Windows and Mac OS (for CUDA 1.1 and later)	Download
CUDA Photoshop Plug-ins: Documentation (for CUDA 1.1 and later)	Download

How to compile ...?

Path Variables:

export LD_LIBRARY_PATH=/usr/local/cuda/lib:
export PATH=/usr/local/cuda/bin:$PATH

NVCC Compiler:

nvcc -O3 main.cu -I/home/tobias/NVIDIA_CUDA_SDK/common/inc
-L/home/tobias/NVIDIA_CUDA_SDK/lib -lcutil

Double Precision:
-arch sm_13

CUDA Example

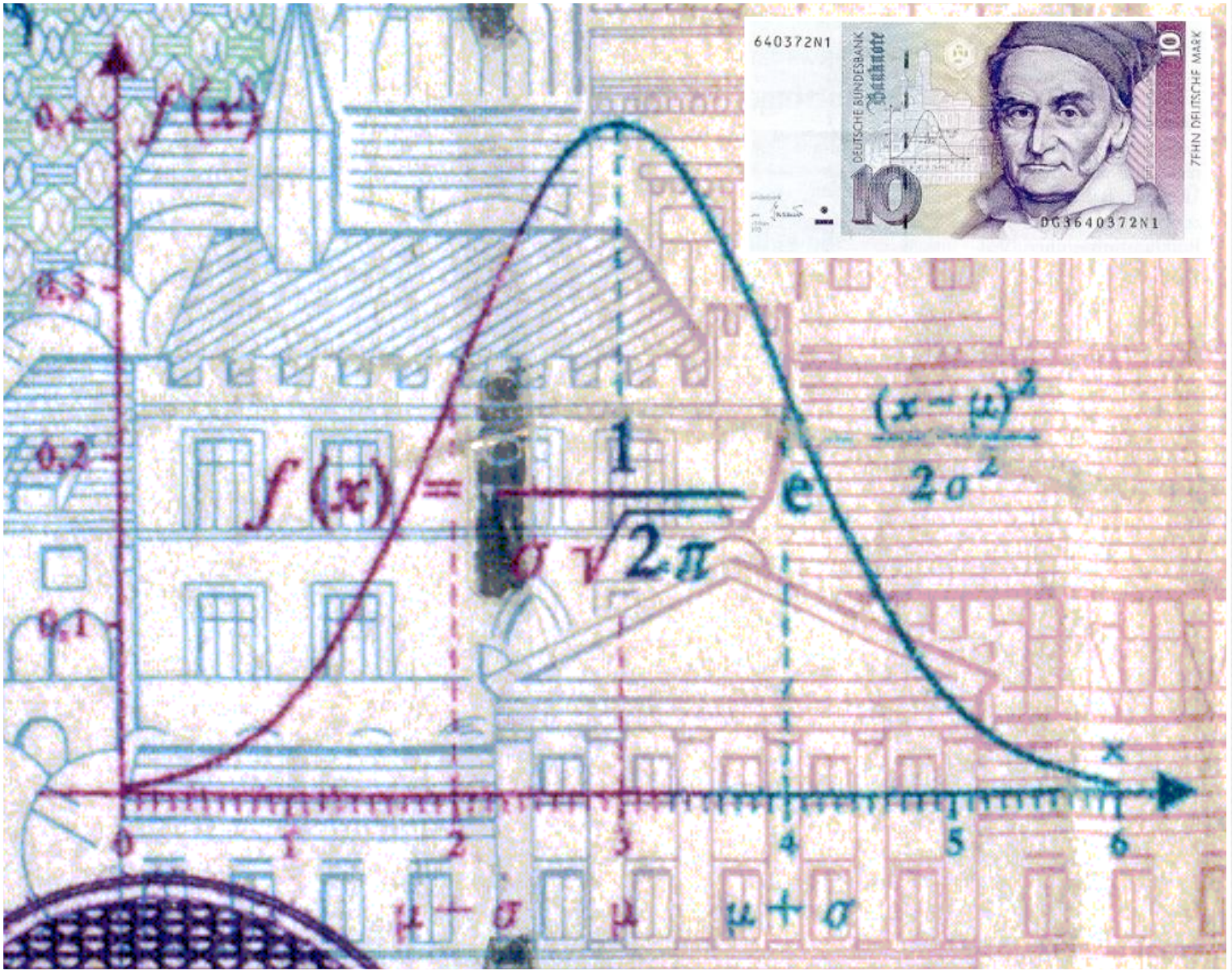
Array manipulation

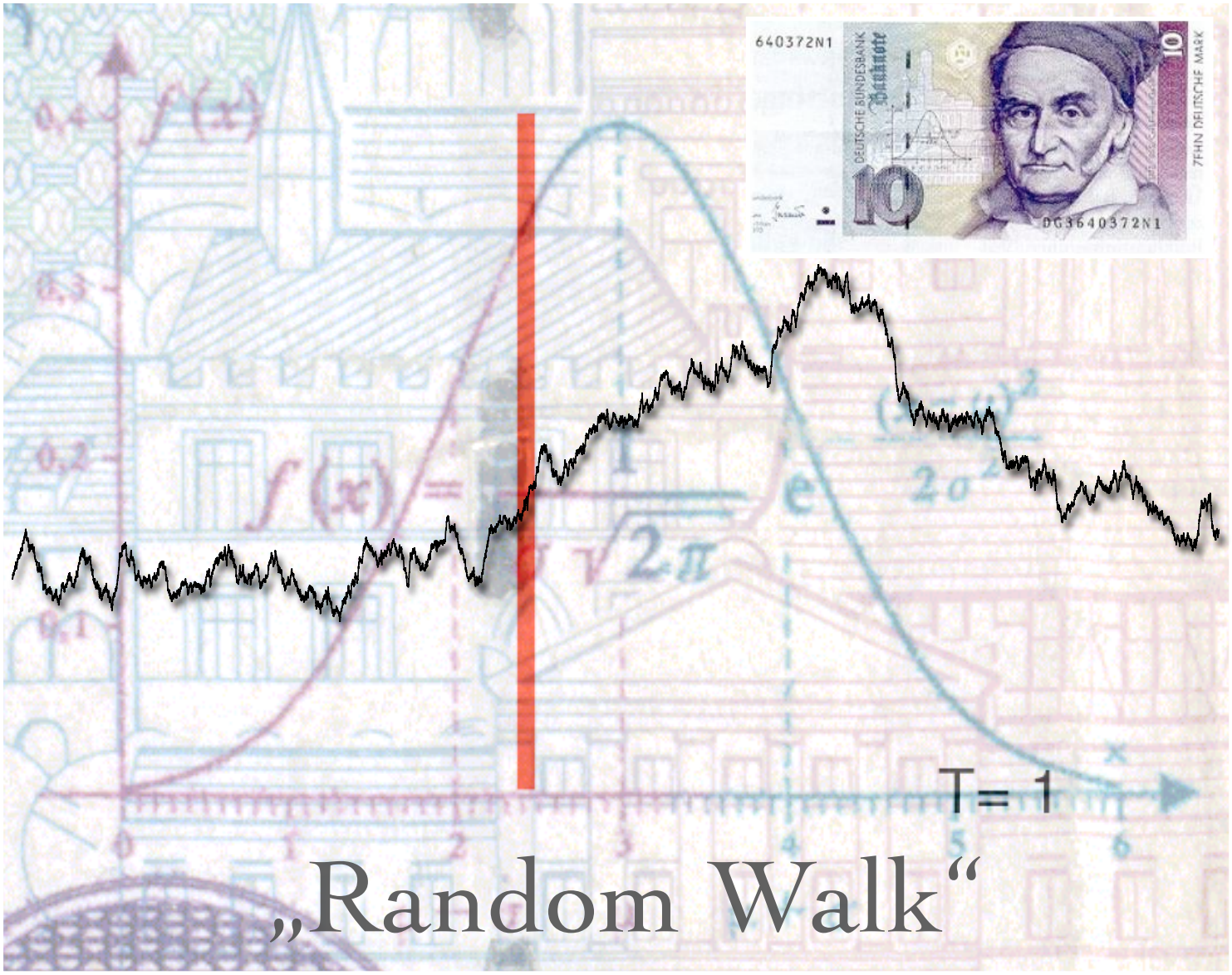
```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include <cutil.h>

#define BLOCK_SIZE 32

__global__ void gpu(float* x) {
  int id=threadIdx.x+BLOCK_SIZE*blockIdx.x;
  x[id]+=1;
}

int main(int argc,char** argv) {

  CUT_DEVICE_INIT(argc,argv);
  unsigned int mem_size=sizeof(float)*512;
  float* x=(float*) malloc(mem_size);
  for(int i=0; i<512;i++) x[i]=1;

  float* d_x;
  CUDA_SAFE_CALL(cudaMalloc((void**) &d_x,mem_size));
  CUDA_SAFE_CALL(cudaMemcpy(d_x,x,mem_size,cudaMemcpyHostToDevice));

  //GPU Function
  gpu<<<16,BLOCK_SIZE>>>(d_x);
  CUDA_SAFE_CALL(cudaMemcpy(x,d_x,mem_size,cudaMemcpyDeviceToHost));

  float sum=0;
  for(int i=0; i<512;i++) sum+=x[i];
  printf("%f \n",sum);
  CUDA_SAFE_CALL(cudaFree(d_x));
}
```

GPGPU / Time Series Analysis

Tobias Preis

GPGPU / Time Series Analysis

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„Random Walk“

German Stock Index (Dax)

20.06.2008

15.09.2008

LEHMAN BROTHERS

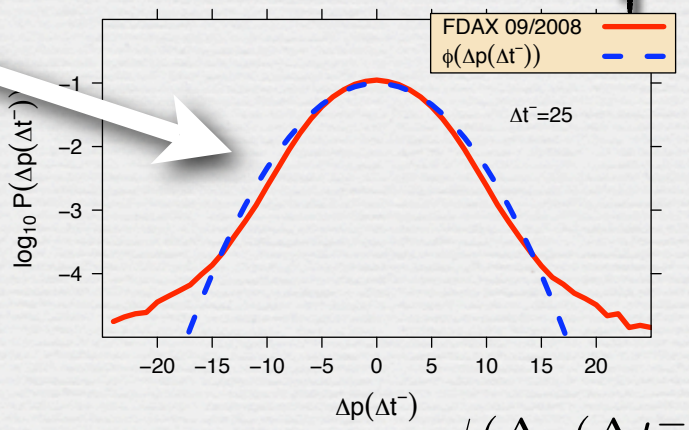
19.09.2008

PDF of returns

Hurst Exponent

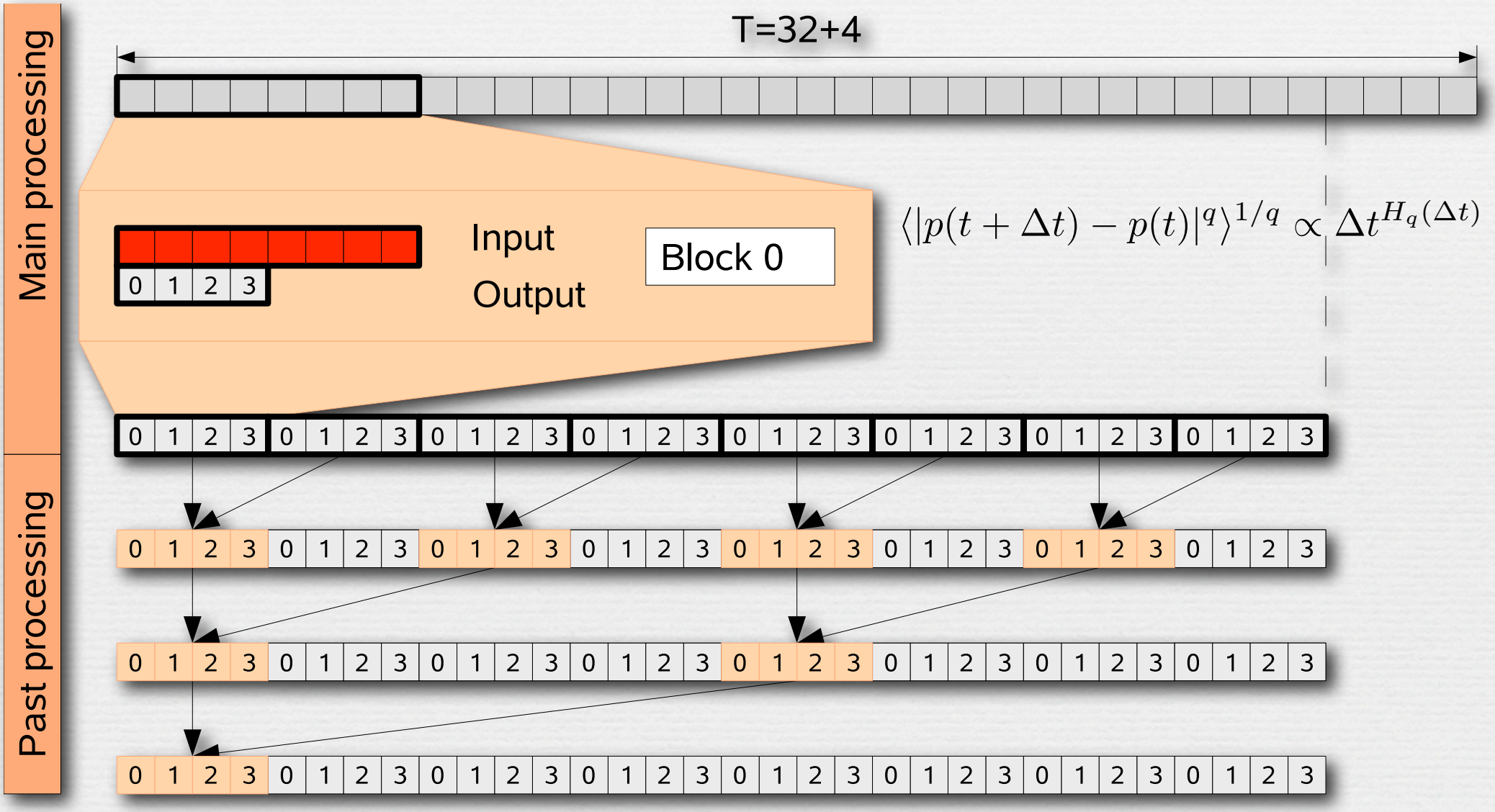
Autocorrelation

Pattern Conformity

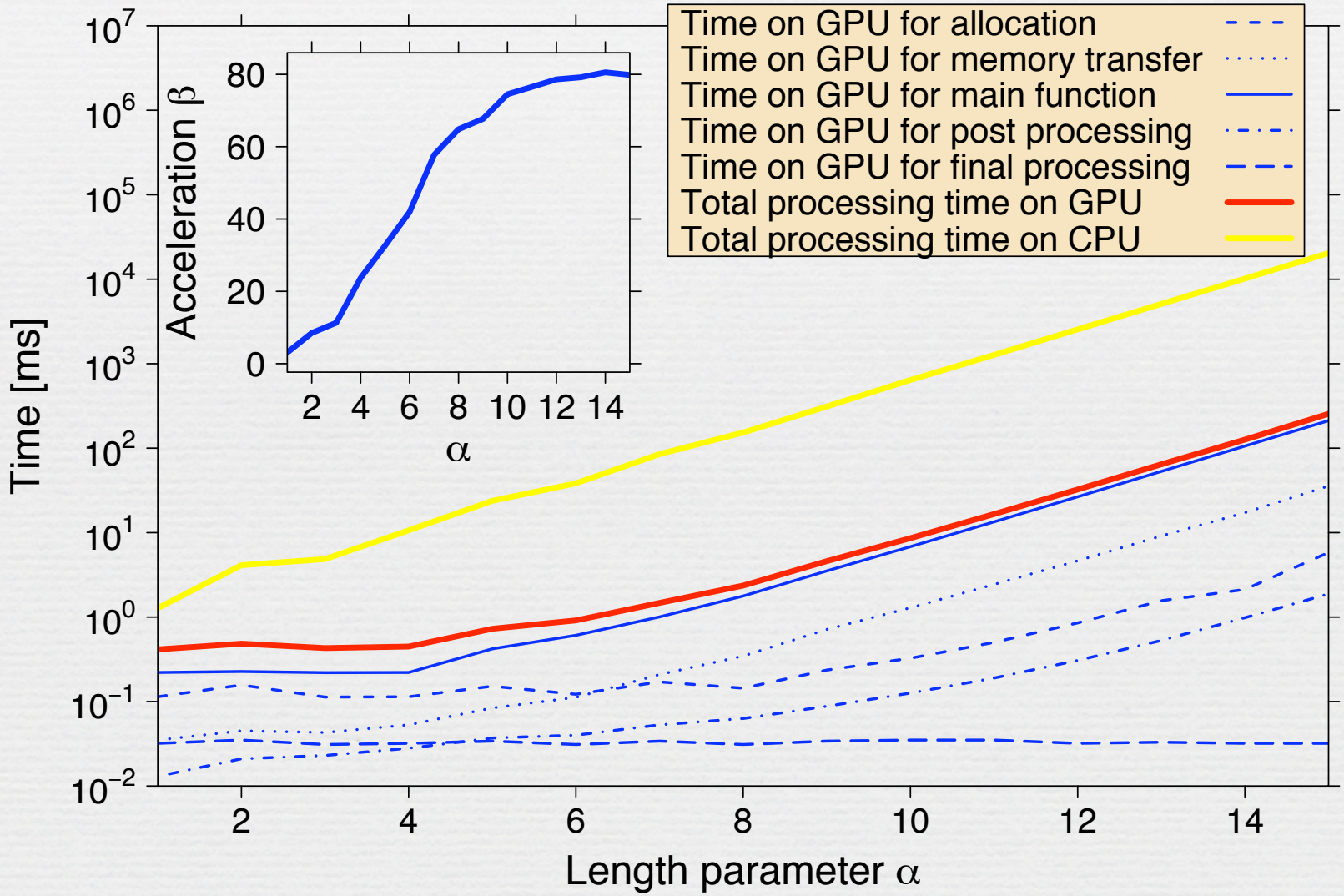


$$\phi(\Delta p(\Delta t^-)) = u \exp(-v \Delta p^2)$$

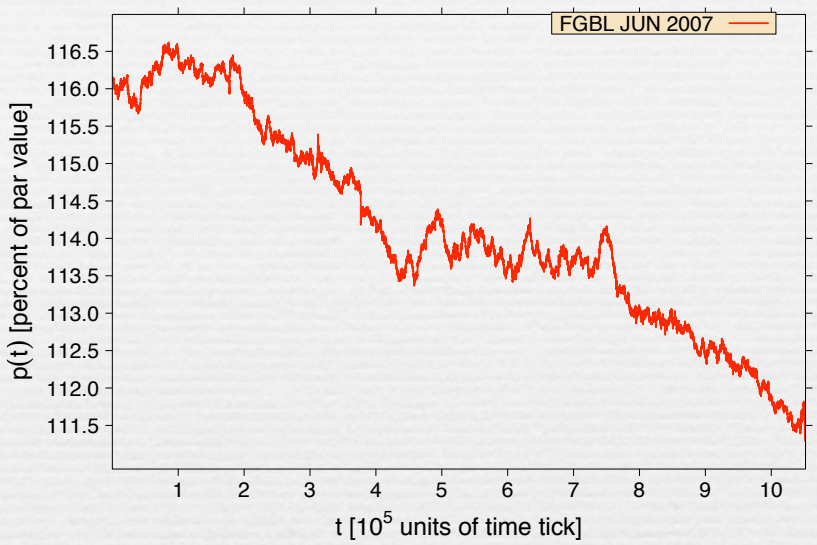
GPU computing / Hurst exponent

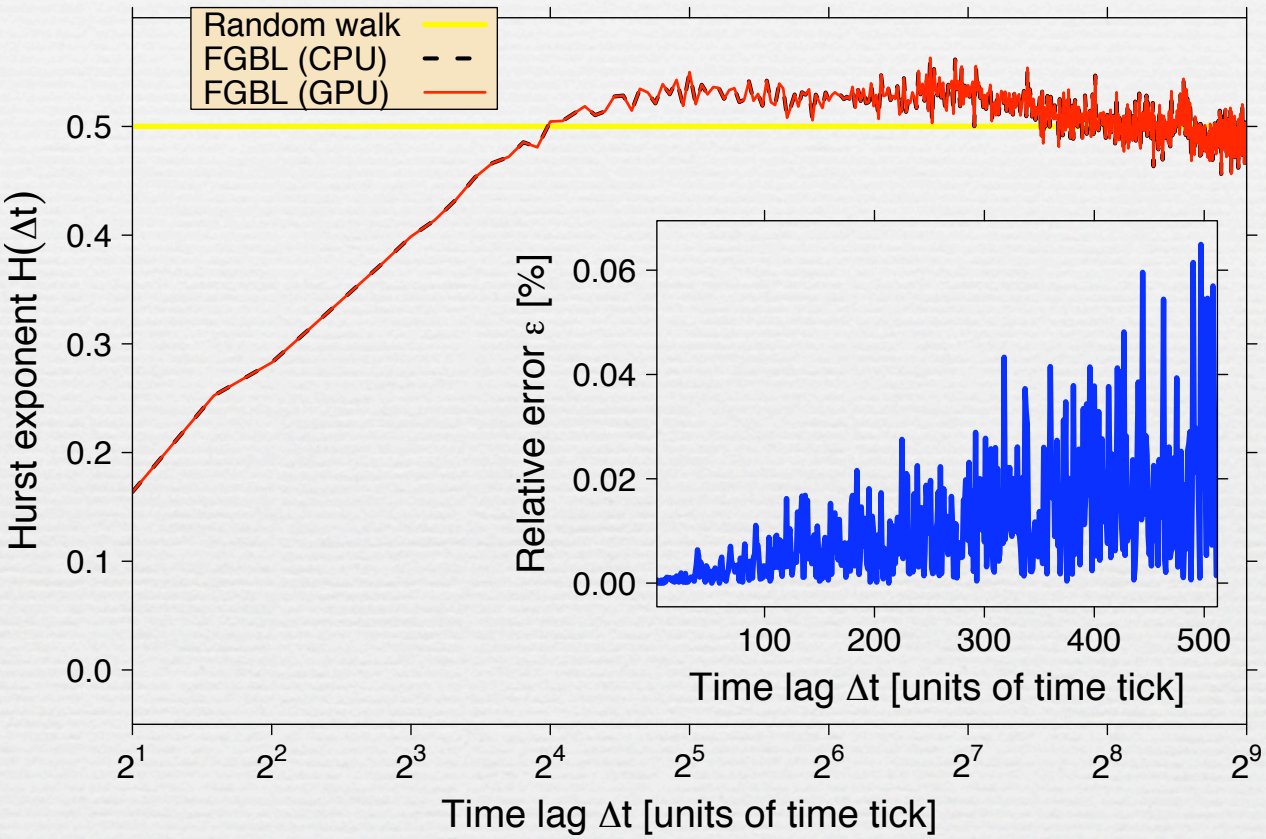


GPU computing / Hurst exponent



GPU computing / Hurst exponent

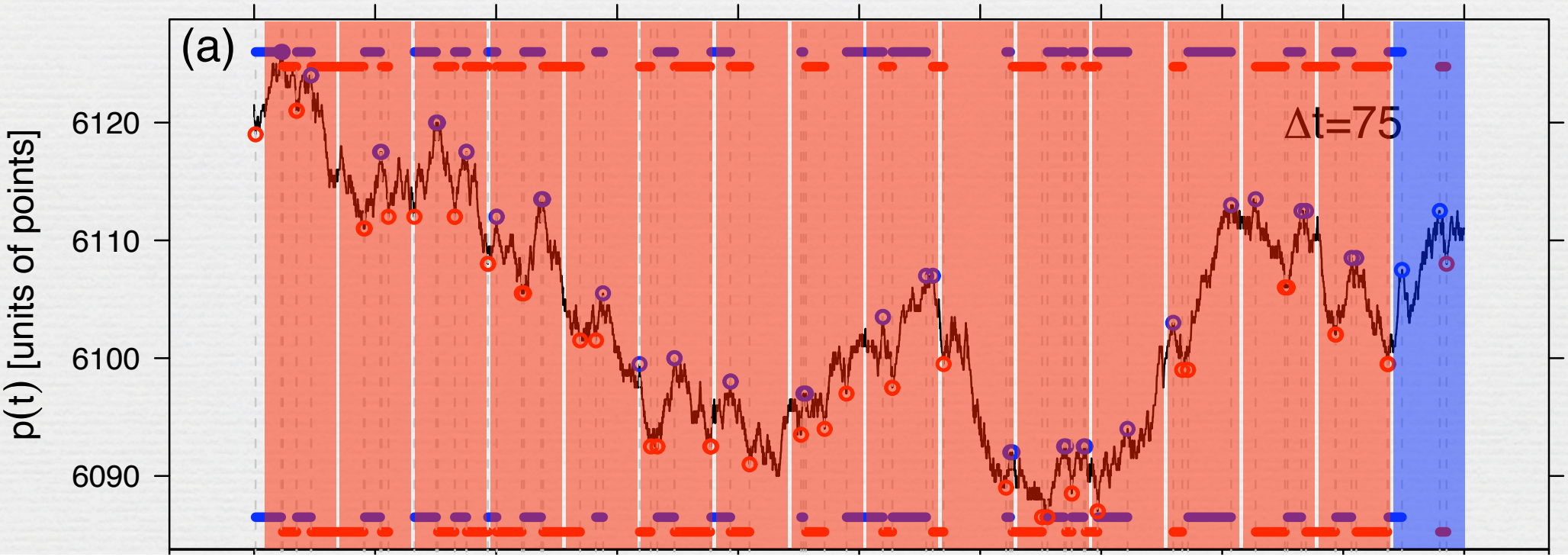




TP, P. Virnau, W. Paul, and J. J. Schneider, Preprint submitted (2009)

Fluctuation Patterns

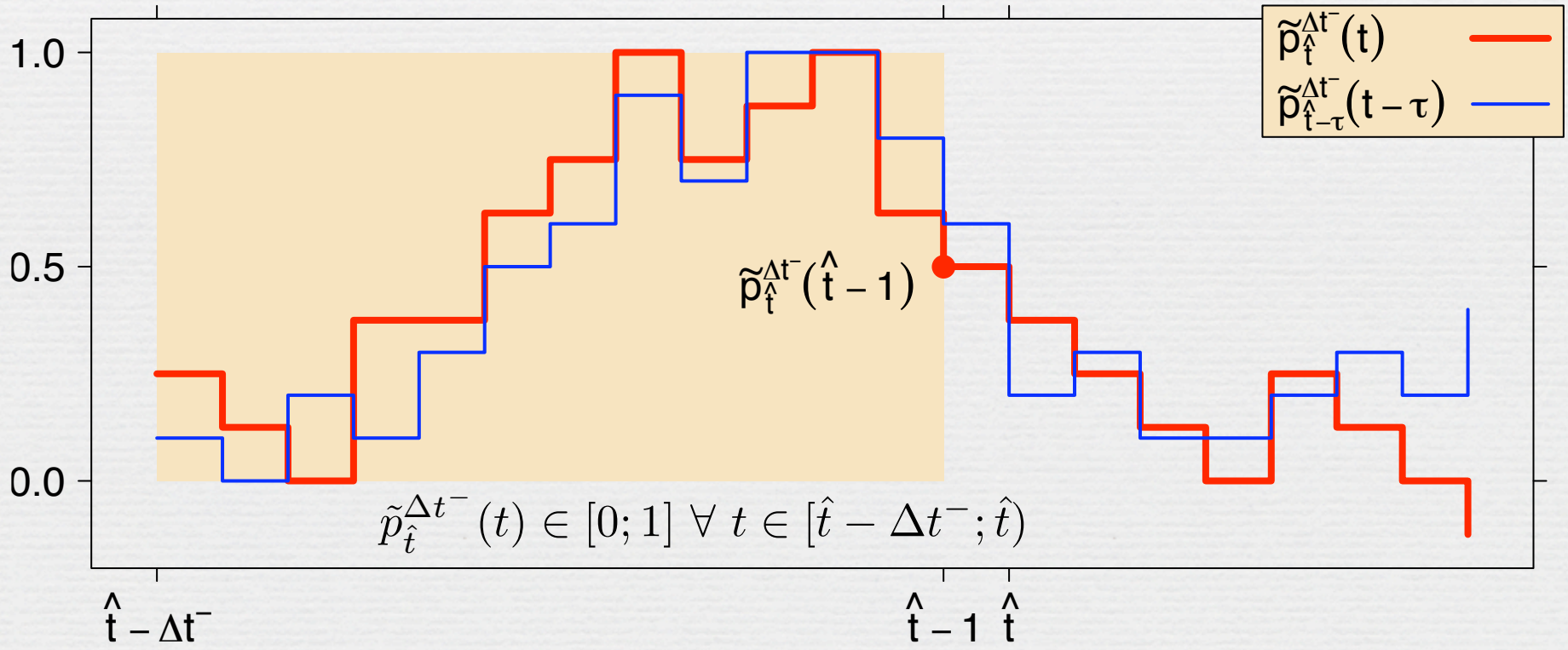
„The aim is to compare the current reference pattern of time interval length Δt^- with all previous patterns in the time series.“



Fluctuation Patterns

True range adapted modified time series $\tilde{p}_{\hat{t}}^{\Delta t^-}(t)$

$$\tilde{p}_{\hat{t}}^{\Delta t^-}(t) = \frac{p(t) - p_l(\hat{t}, \Delta t^-)}{p_h(\hat{t}, \Delta t^-) - p_l(\hat{t}, \Delta t^-)}$$

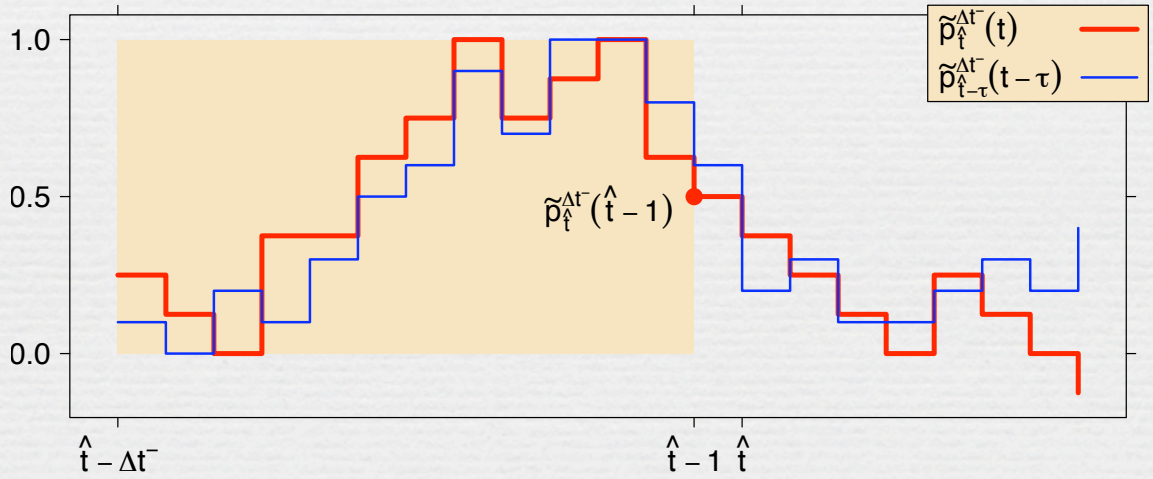


Fluctuation Patterns

Mean-square quality between current and comparison sequence

$$Q_{\hat{t}}^{\Delta t^-}(\tau) = \sum_{\theta=1}^{\Delta t^-} \frac{\left(\tilde{p}_{\hat{t}}^{\Delta t^-}(\hat{t}-\theta) - \tilde{p}_{\hat{t}-\tau}^{\Delta t^-}(\hat{t}-\tau-\theta)\right)^2}{\Delta t^-}$$

with $Q_{\hat{t}}^{\Delta t^-}(\tau) \in [0,1]$



In order to quantify the value of reference and comparison pattern relative to the reference point, one can define ...

$$\omega_{\hat{t}}^{\Delta t^-}(\tau,\Delta t^+) = \left(\tilde{p}_{\hat{t}}^{\Delta t^-}(\hat{t}-1+\Delta t^+) - \tilde{p}_{\hat{t}}^{\Delta t^-}(\hat{t}-1)\right)\cdot\left(\tilde{p}_{\hat{t}-\tau}^{\Delta t^-}(\hat{t}-\tau-1+\Delta t^+) - \tilde{p}_{\hat{t}}^{\Delta t^-}(\hat{t}-1)\right)$$

Fluctuation Patterns

Observable for pattern conformity:

$$\xi_\chi\left(\Delta t^+,\Delta t^-\right) = \sum_{\hat{t}=\Delta t^-}^{T-\Delta t^+} \sum_{\tau=\tau^*}^{\hat{t}} \frac{\operatorname{sgn}\left(\omega_{\hat{t}}^{\Delta t^-}\left(\tau,\Delta t^+\right)\right)}{\exp\left(\chi Q_{\hat{t}}^{\Delta t^-}(\tau)\right)}$$

Limitation: $\tau^* = \begin{cases} \hat{t}-\hat{\tau} & \text{if } \hat{t}-\hat{\tau}-\Delta t^- \geq 0 \\ \Delta t^- & \text{else} \end{cases}$

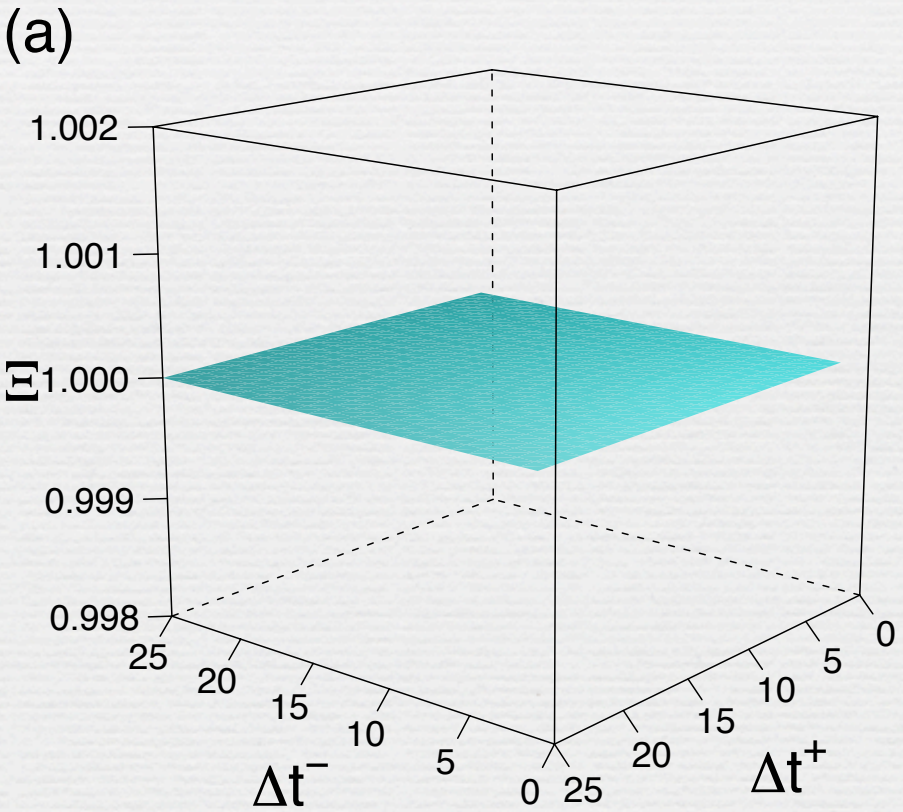
Definition: $\operatorname{sgn}(x) = \begin{cases} 1 & \text{for } x > 0 \\ 0 & \text{for } x = 0 \\ -1 & \text{for } x < 0 \end{cases}$

Normalized pattern conformity:

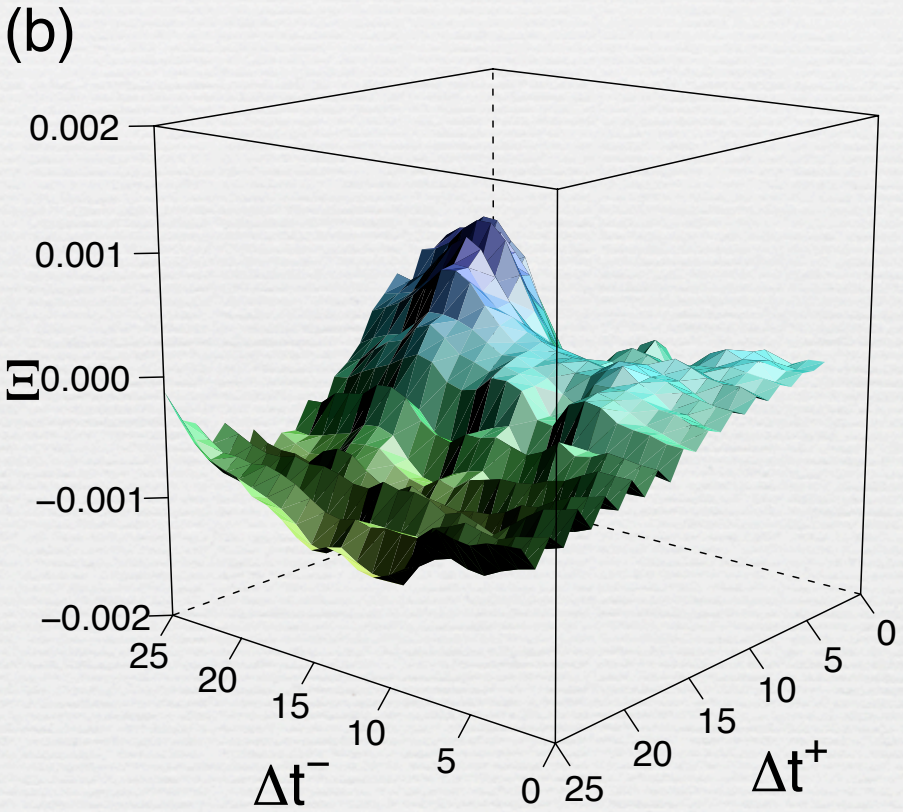
$$\Xi_\chi\left(\Delta t^+,\Delta t^-\right) = \frac{\xi_\chi\left(\Delta t^+,\Delta t^-\right)}{\sum_{\hat{t}=\Delta t^-}^{T-\Delta t^+} \sum_{\tau=\tau^*}^{\hat{t}} \frac{\left|\operatorname{sgn}\left(\omega_{\hat{t}}^{\Delta t^-}\left(\tau,\Delta t^+\right)\right)\right|}{\exp\left(\chi Q_{\hat{t}}^{\Delta t^-}(\tau)\right)}}$$

Pattern Conformity / Trivial Cases

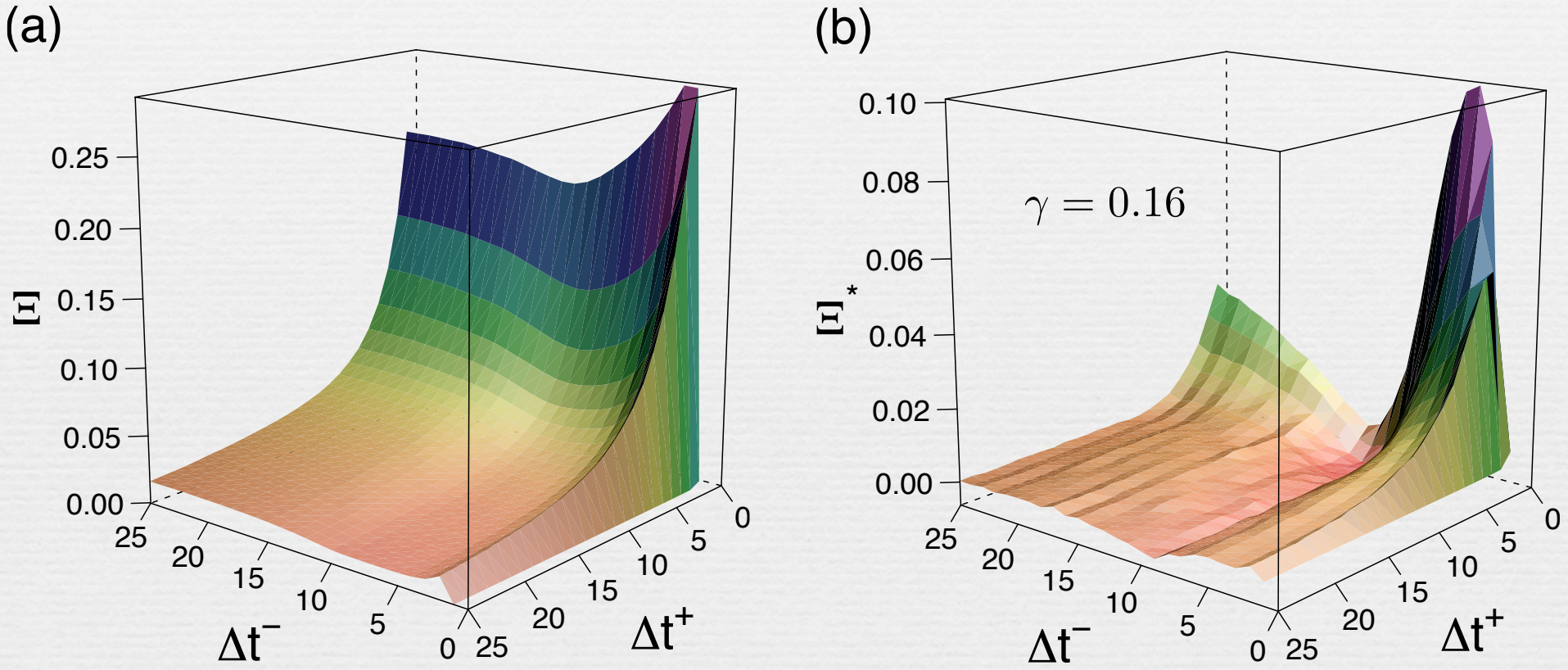
- Straight Line



- Random Walk



Pattern Conformity / FDAX



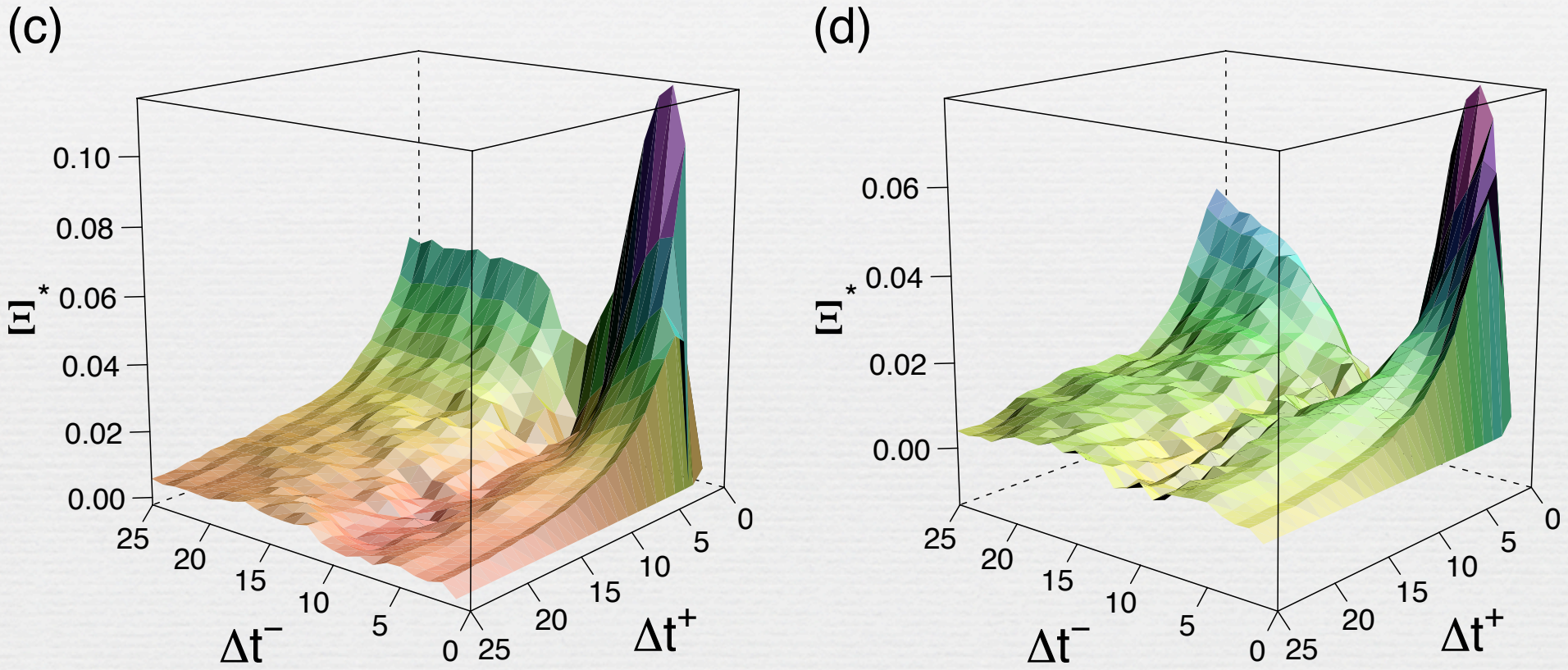
Complex correlations for financial market time series – especially for large pattern lengths.

$$\Xi^{*} = \Xi^{\mathrm{FDAX}}_{\chi=100} - \Xi^{\mathrm{ACRW}}_{\chi=100}$$

$$Q^{\Delta t^{-}}_{\hat{t}}(\tau) = Q^{p,\Delta t^{-}}_{\hat{t}}(\tau)$$

Inclusion of volumes and ITWT

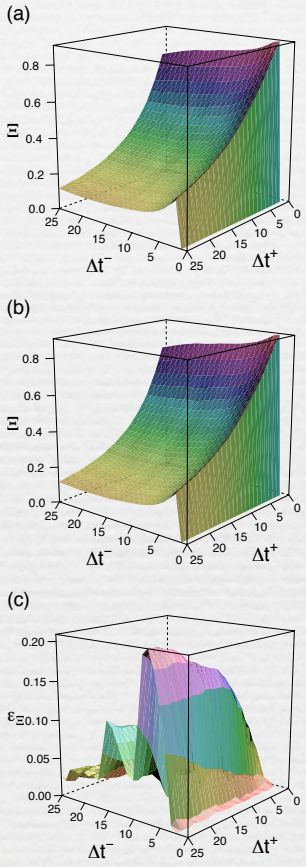
T. Preis et al., Europhys. Lett. **82**, 68005 (2008)

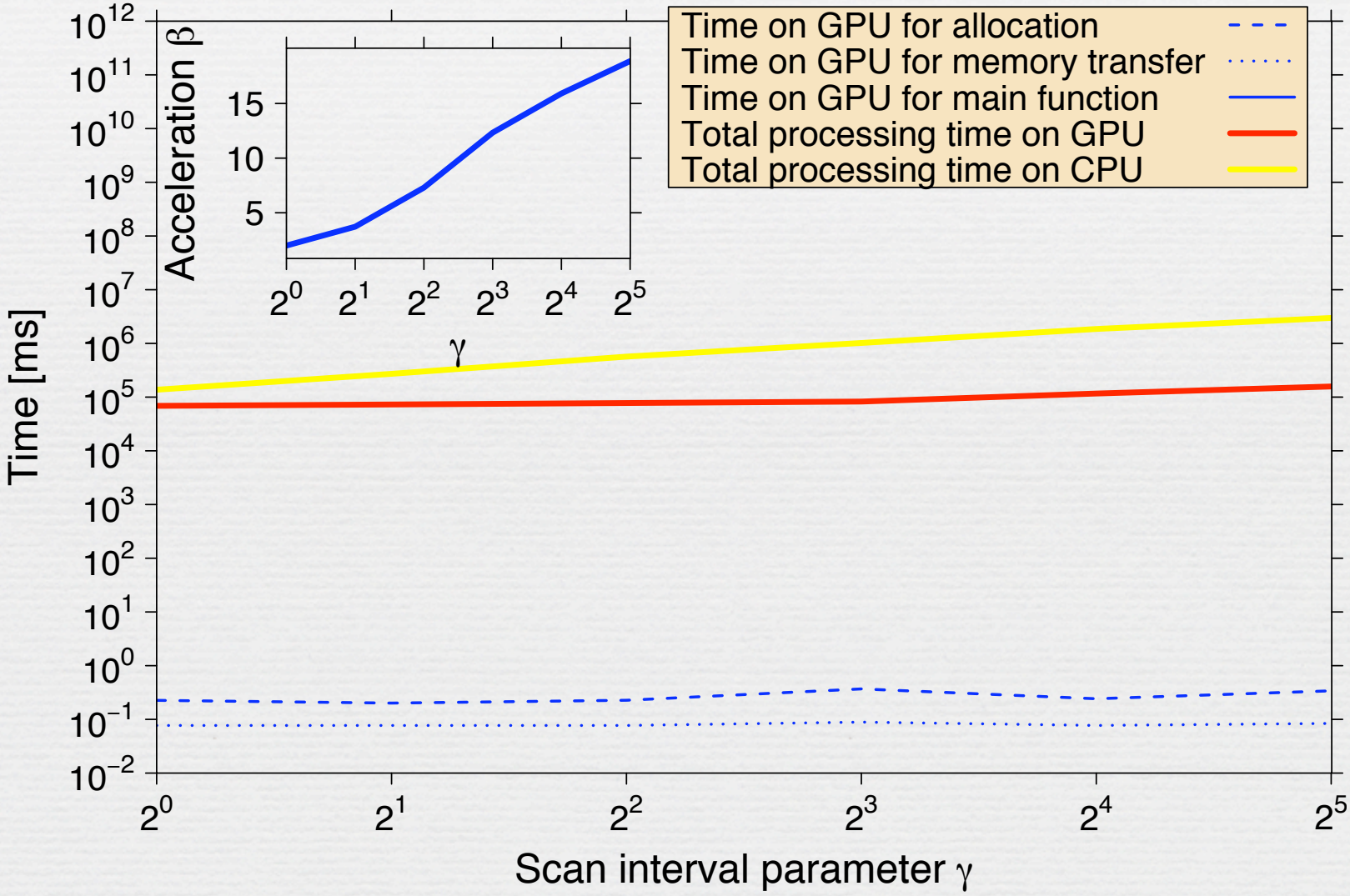


Same structure – high values of the pattern conformity

$$Q_{\hat{t}}^{\Delta t^-}(\tau) = Q_{\hat{t}}^{p,\Delta t^-}(\tau) + Q_{\hat{t}}^{v,\Delta t^-}(\tau) \qquad Q_{\hat{t}}^{\Delta t^-}(\tau) = Q_{\hat{t}}^{p,\Delta t^-}(\tau) + Q_{\hat{t}}^{\iota,\Delta t^-}(\tau)$$

GPU computing / Pattern Conformity





Final remarks

- TP, PV, WP, and JJS, „Accelerated Fluctuation Analysis by Graphic Cards and Complex Pattern Formation in Econophysics“, Preprint submitted (2009)

Thank you!